Comparison of mean age of air in five reanalyses using the BASCOE transport model

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We present a consistent intercomparison of the mean Age of Air (AoA) according to five modern reanalyses: ERA-Interim, JRA-55, CFSR, MERRA and MERRA-2. The modeling tool, a kinematic transport model driven only by the surface pressure and wind fields, is validated for ERA-I and MERRA through a comparison with the AoA computed by two other transport models. The five reanalyses deliver surprisingly different and diverse AoA. At all latitudes and altitudes, MERRA-2 and MERRA provide the oldest values while JRA-55 and CFSR provide the youngest values and ERA-I delivers intermediate results. The spread of AoA at 50 hPa is as large as the spread obtained in a comparison of Chemistry-Climate Models and in the northern mid-latitudes of the mid-stratosphere it is as large as the observational uncertainties in a multi-decadal time series of balloon observations. The differences between tropical and mid-latitudes AoA indicate that the upwelling is too fast in the tropical lower stratosphere. No global impact of the Pinatubo eruption can be found in our simulations of AoA, contrarily to a recent study which used a diabatic transport model driven by ERA-I and JRA-55 winds and heating rates.

The time variations are also analyzed through multiple linear regression analyses taking into account the seasonal cycles, the Quasi-Biennal Oscillation and the linear trends over four time periods. The amplitudes of AoA seasonal variations are significantly larger using MERRA and MERRA-2 than with the other reanalyses. The linear trends of AoA using ERA-I confirm those found by earlier model studies, especially for the period 2002-2012 where the dipole structure of the latitude-height distribution also matches trends derived from satellite observations of SF_6. Yet the linear trends vary considerably depending on the considered period. Over 2002-2015 the ERA-I results still show a dipole structure but it is much less pronounced. No reanalysis other than ERA-I finds any dipole structure of AoA trends. Using ERA-I and CFSR, the 2002-2015 trends are negative above 10 hPa but using the three other reanalyses these trends are positive. Over the whole period 1989-2015 each reanalysis delivers opposite trends, i.e. AoA is mostly increasing with ERA-I and CFSR but mostly decreasing with JRA-55, MERRA and MERRA-2. In view of these large disagreements, we urge great caution for studies aiming to assess AoA trends derived only from reanalysis winds. We briefly discuss some possible causes for the dependency of AoA on the input reanalysis and highlight the need for complementary intercomparisons using diabatic transport models.

Key words: Brewer-Dobson Circulation, dynamics, stratosphere, reanalyses